Liquid Argon Time Proje
Chamber In a testbeam

The little detector that could.

particle classification using Neural networks

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“A billion Neutrinos go swimming: one gets wet.” michael kamakana

Liquid Argon in a testbeam

The little detector with a big heart.

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current particle identification methods

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Deep Learning

Liquid argon Time projection chamber in a testbeam

Why liquid argon?

Abundance

Argon makes up 1% of the atmosphere

Density

Liquid argon is 40% more dense than water.

Ionization

Argon can be readily ionized.

Scintillation

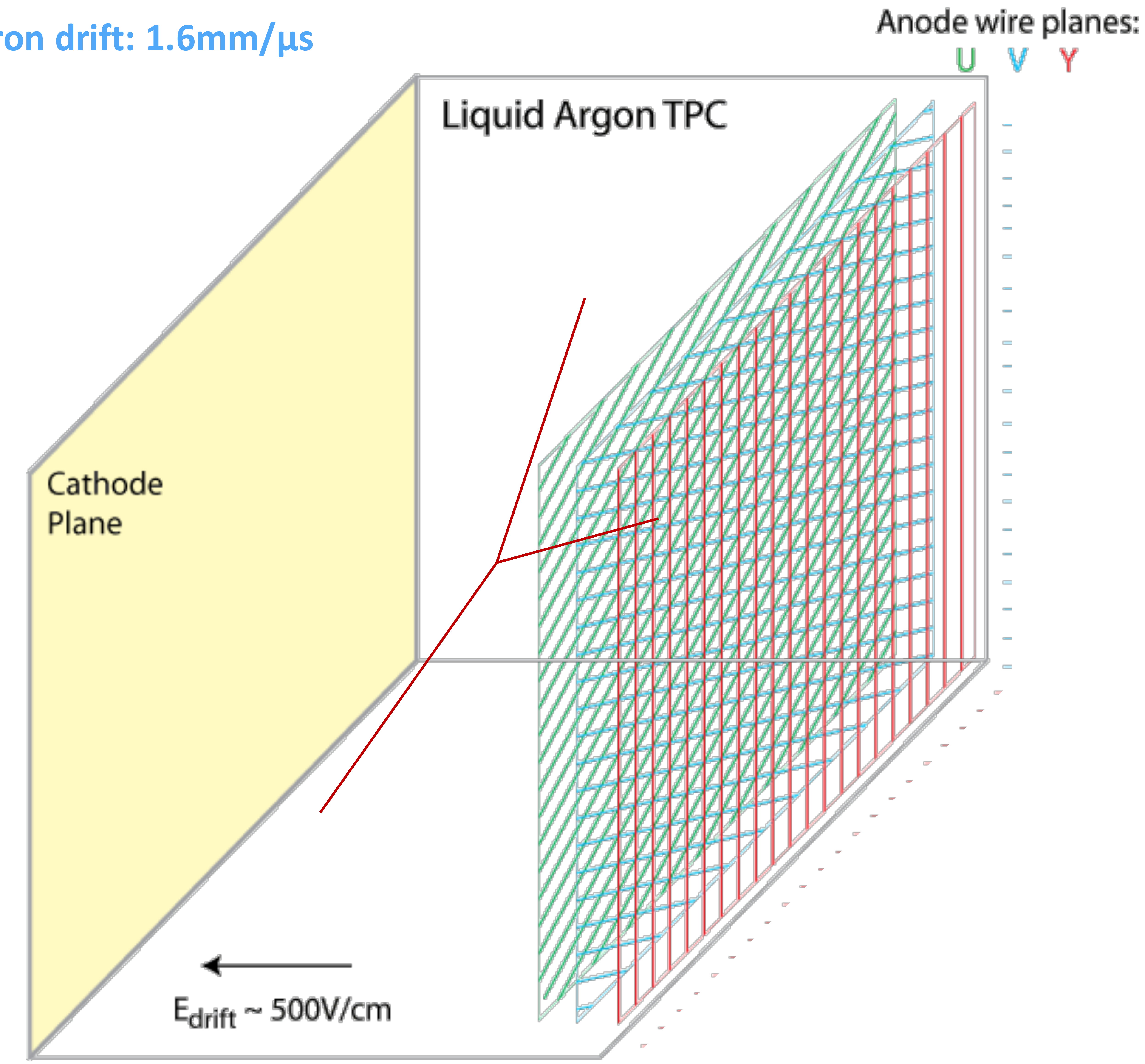
Produces light and is transparent to the light produced.

Electron Lifetime

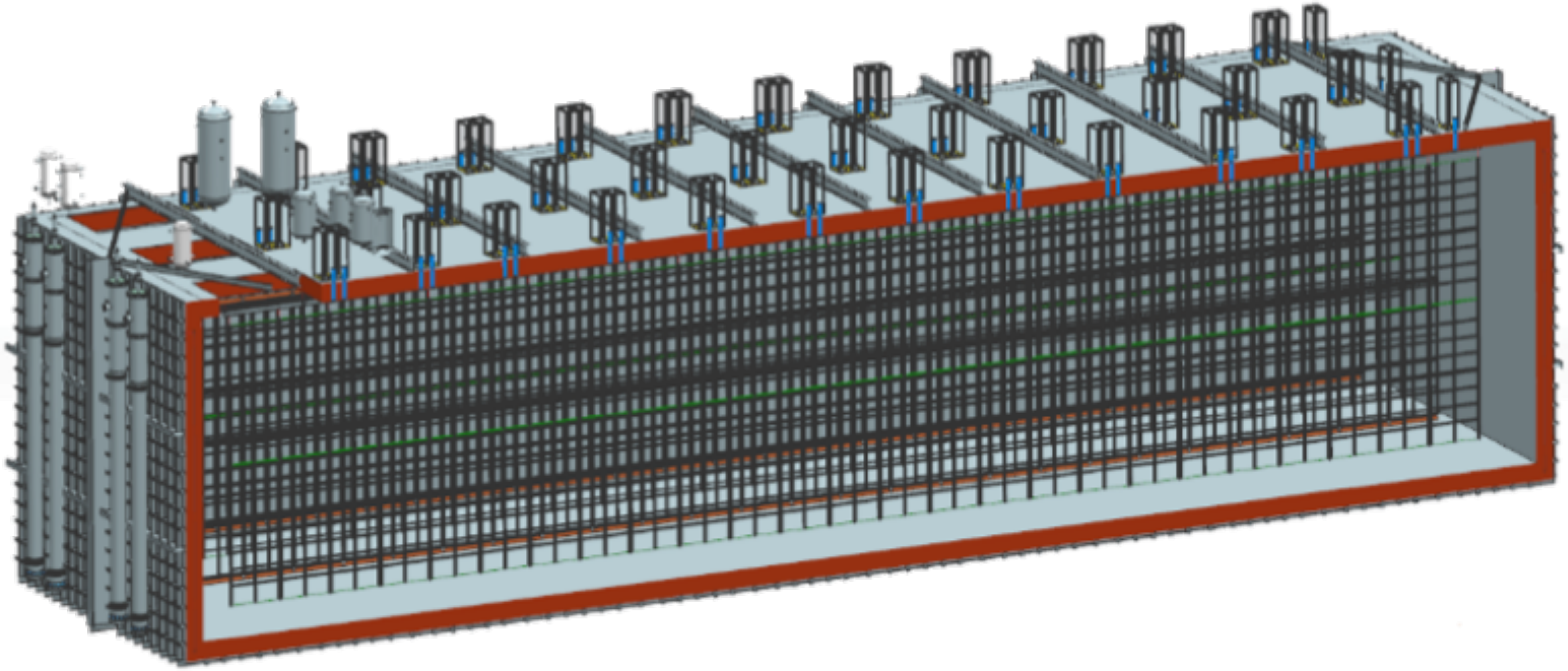
Greek name means “inactive”

Liquid Argon Time Projection Chamber

Electron drift: 1.6mm/μs

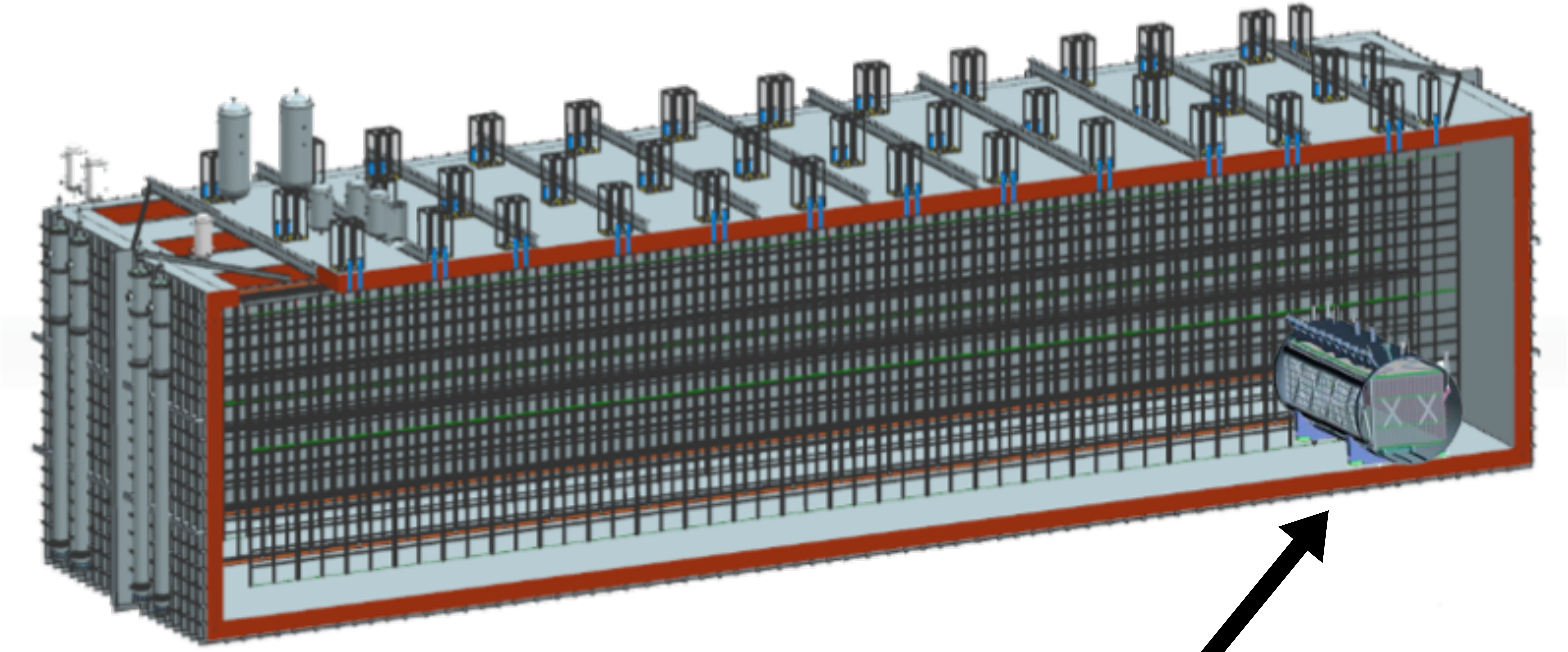


Liquid Argon Time Projection Chamber



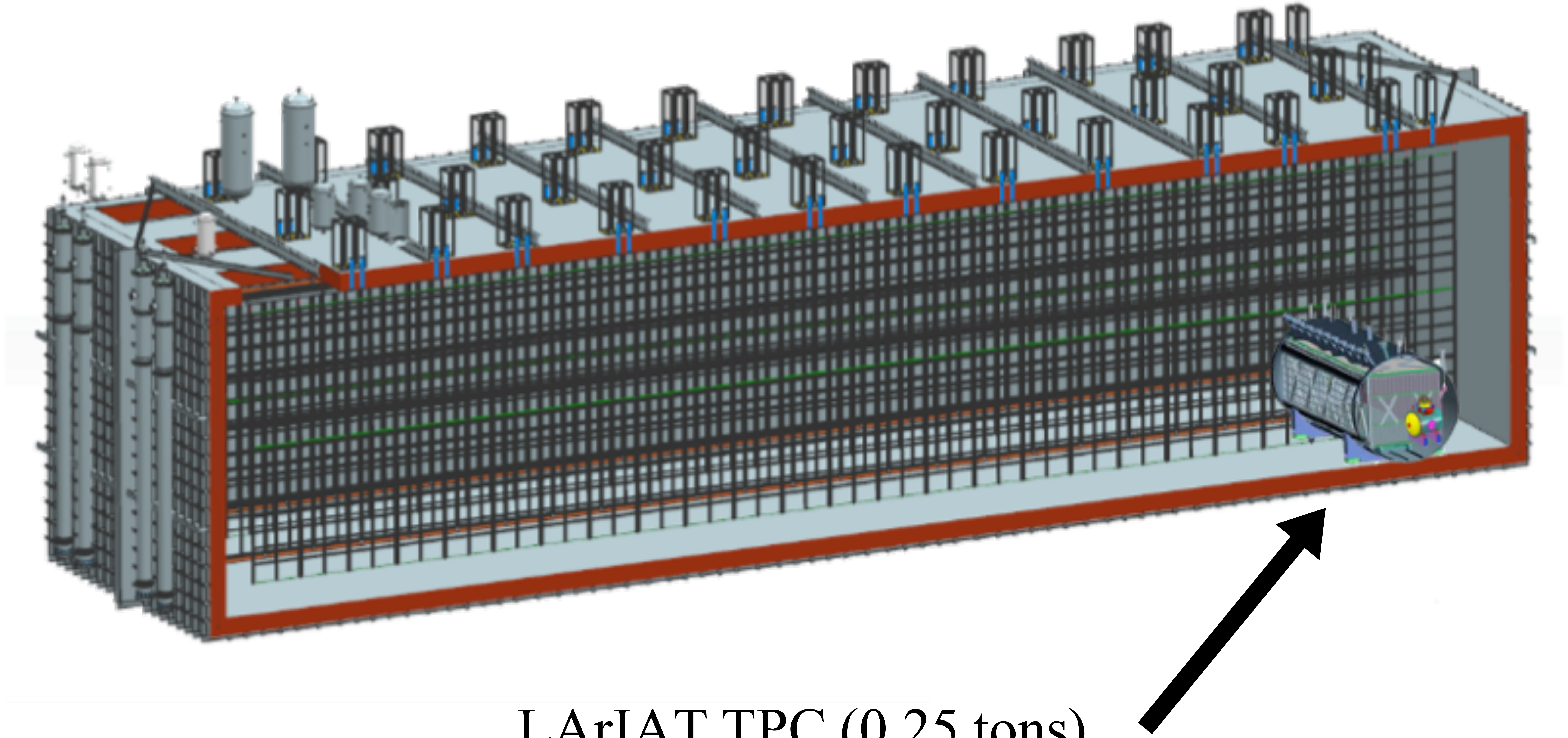
One 10kT DUNE LArTPC Module
18m x 19m x 66m

Liquid Argon Time Projection Chamber



MicroBooNE TPC (80 tons)
2.2m x 2.5m x 10m

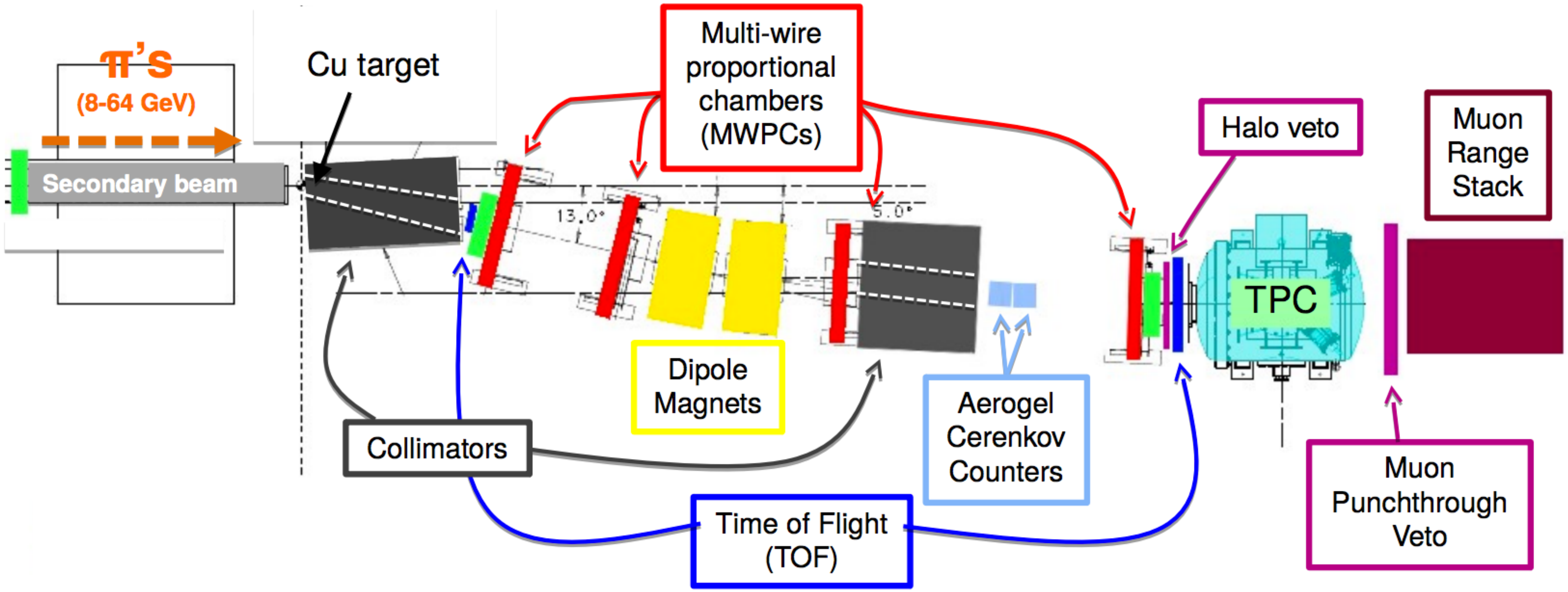
Liquid Argon Time Projection Chamber

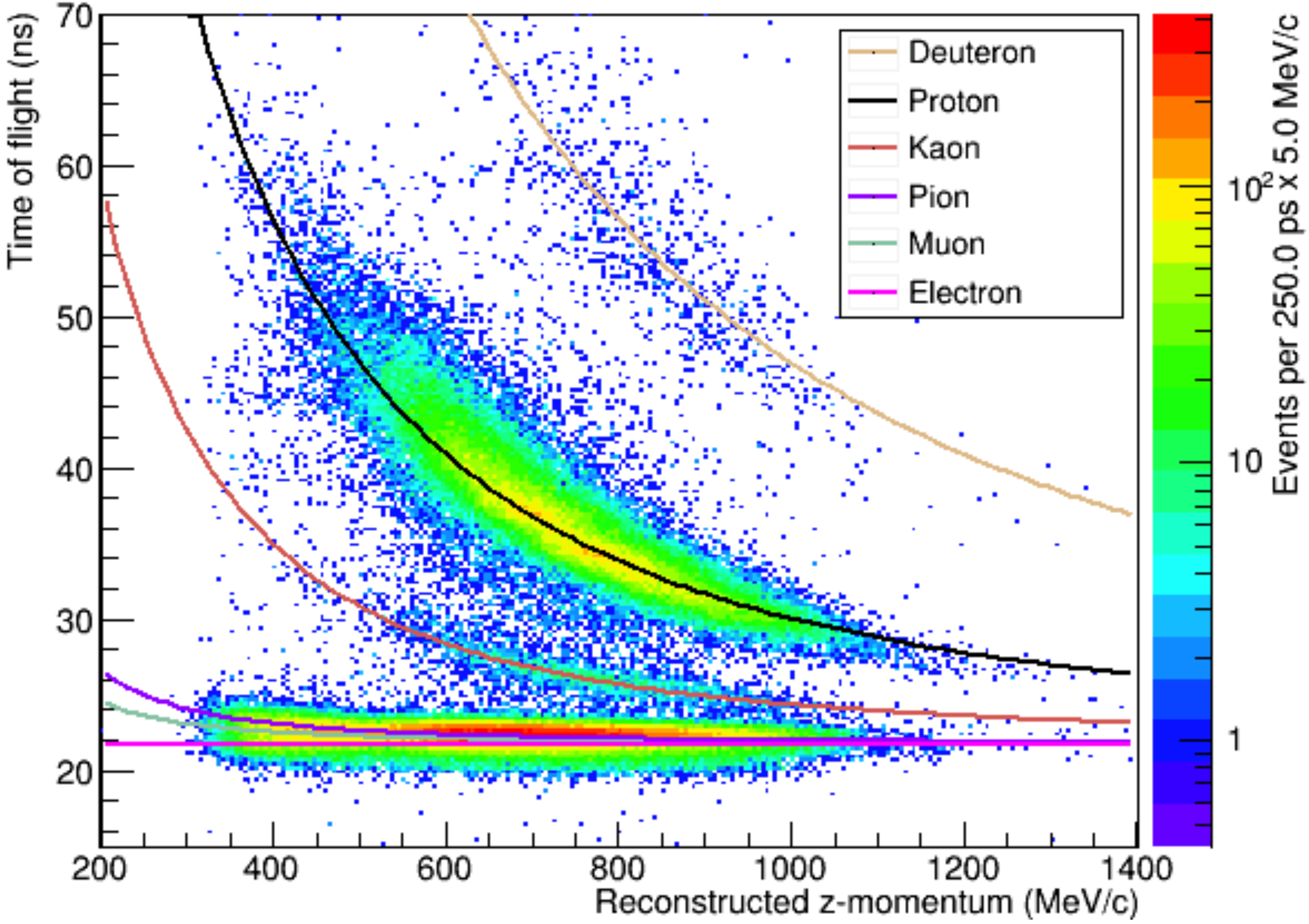


LArIAT TPC (0.25 tons)
0.4m x 0.47m x 0.9m

Current particle identification methods

Liquid Argon In a testbeam





Liquid Argon In a testbeam

Deep Learning

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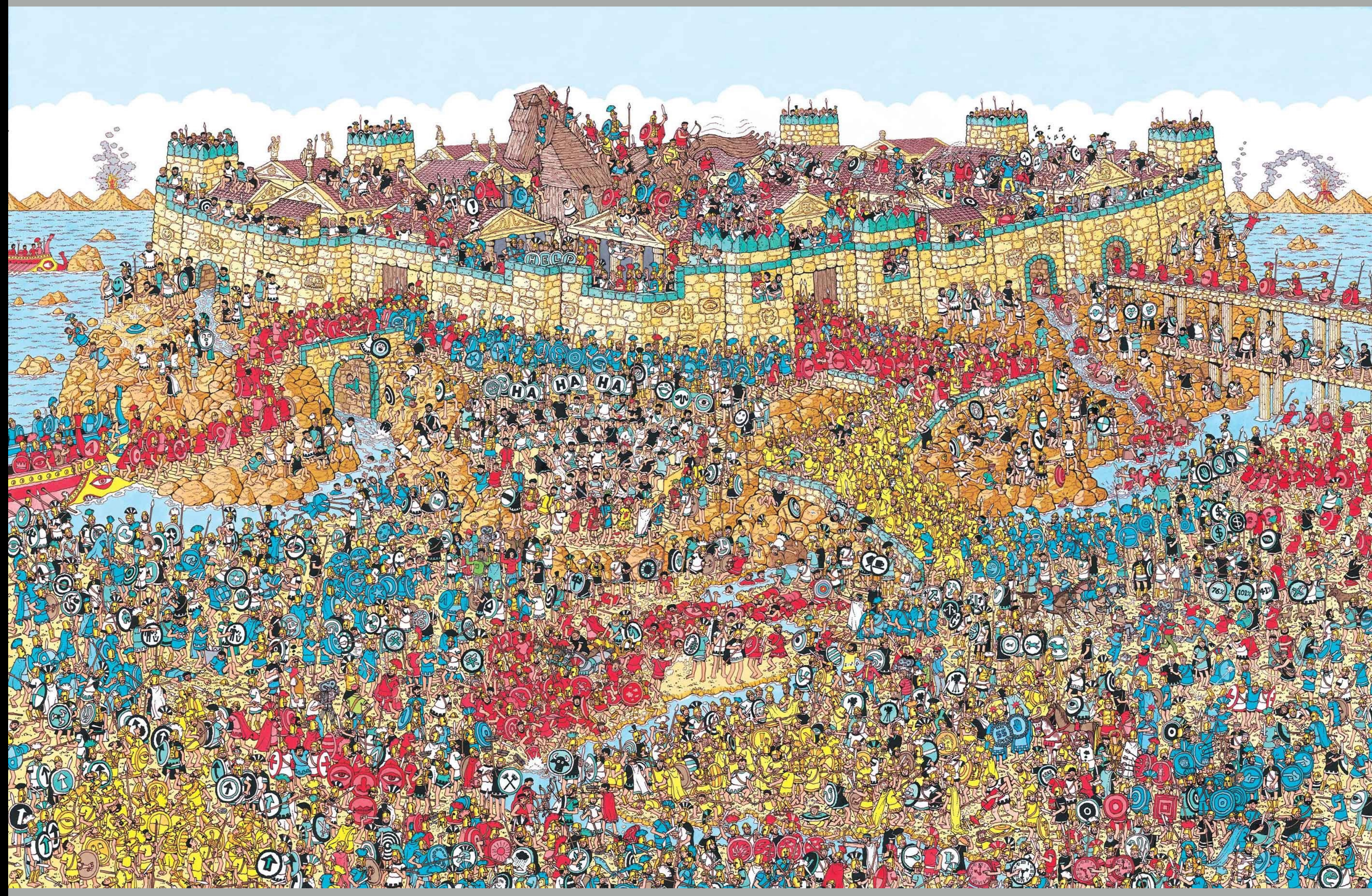
Template Matching

Prototype Matching



Feature Analysis

Pattern Recognition

Two kinds of machine learning

Supervised Learning

output relationship

In supervised learning, we are given a data set and already know what the correct output should look like.

Regression

In regression problems, we are trying to predict results within a continuous output.

Example: An output trying to predict the price of houses based on the real estate market

Classification

In classification problems, we are trying to predict results with a discrete output.

Example: An output to determine whether a house will sell for more or less than the asking price.

UnSupervised Learning

No desired output

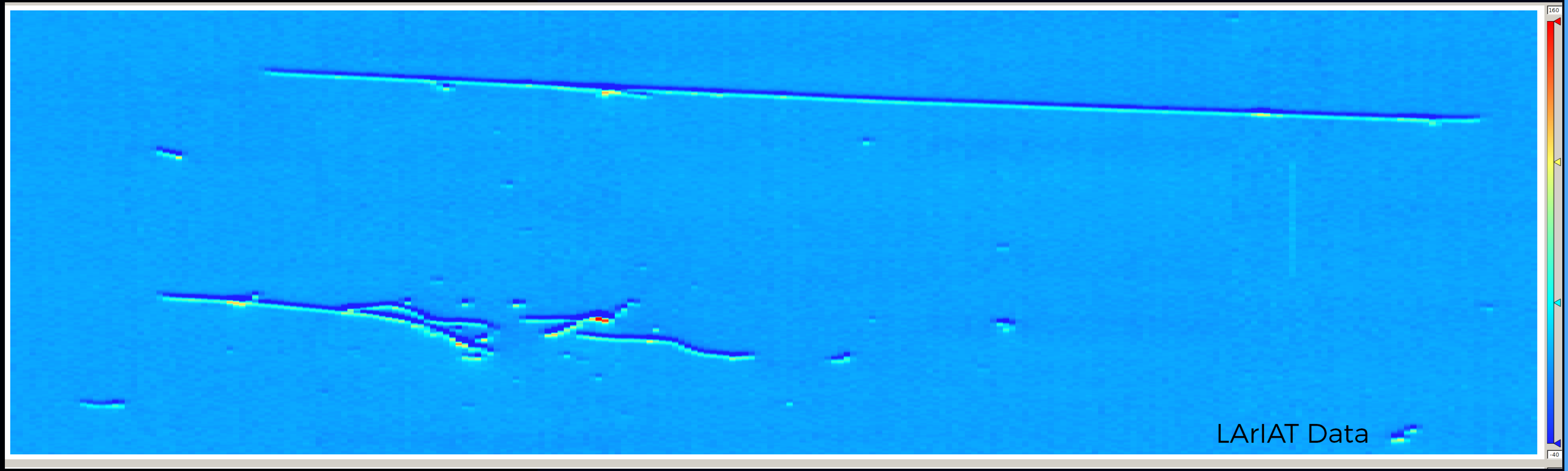
In unsupervised learning, we can approach problems with no particular idea of what our results will look like.
Our structure will cluster data based on undefined variables to find patterns and relationships.

clustering

Say you were handed a stack of note cards with pictures and words on them. You could feed them into an unsupervised learning software and it will try to find a way to group these notecards based on features it sees.

Our Problem

I want to be able to feed our event display images into a neural network who will then classify the tracks into specific particles.



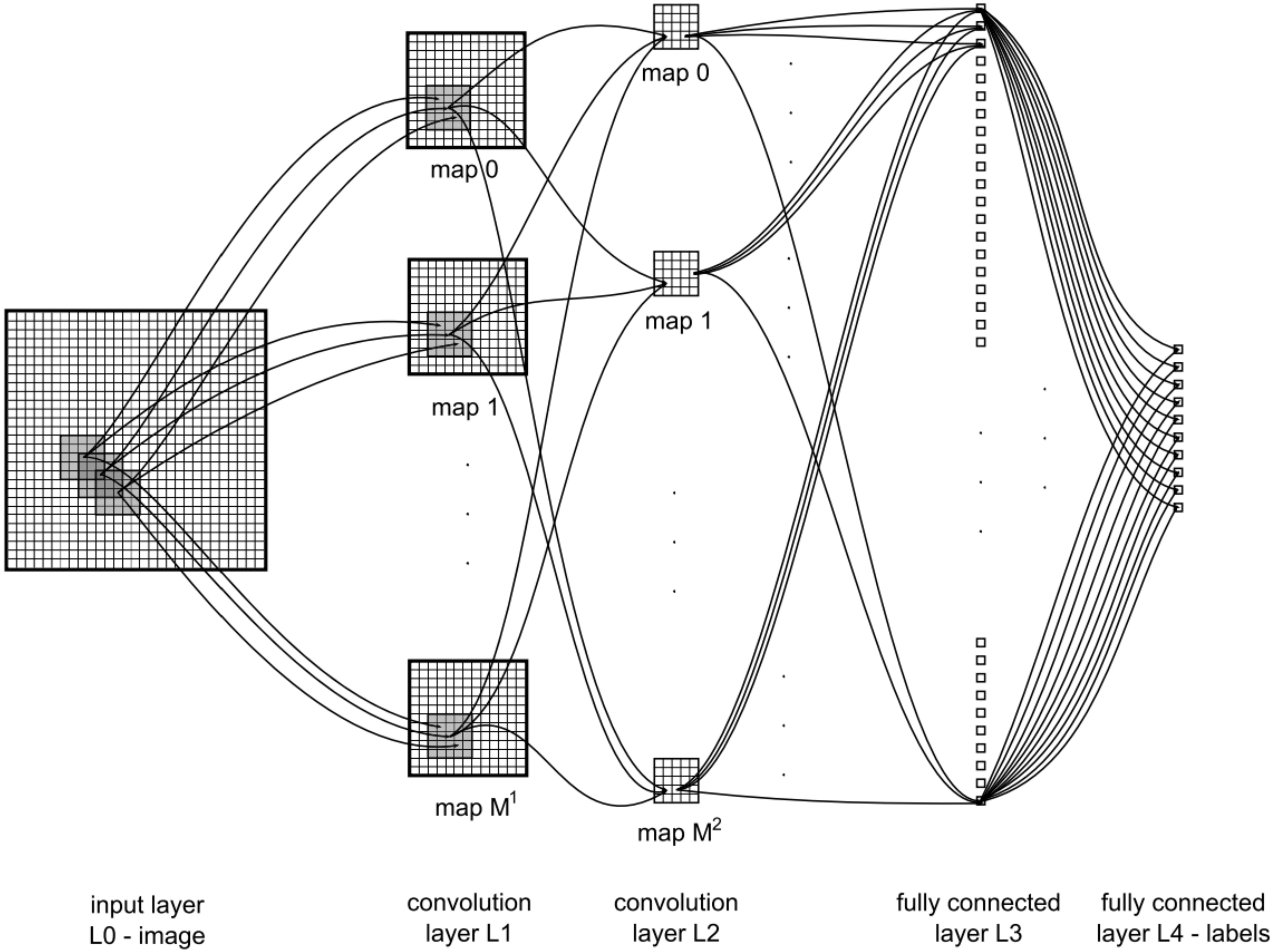
Convolutional Neural Network

Convolutional Neural Networks are based off of biology. A study conducted at Harvard Medical School on macaque and spider monkeys found three classifications of the cells of the visual cortex.

Simple Cells

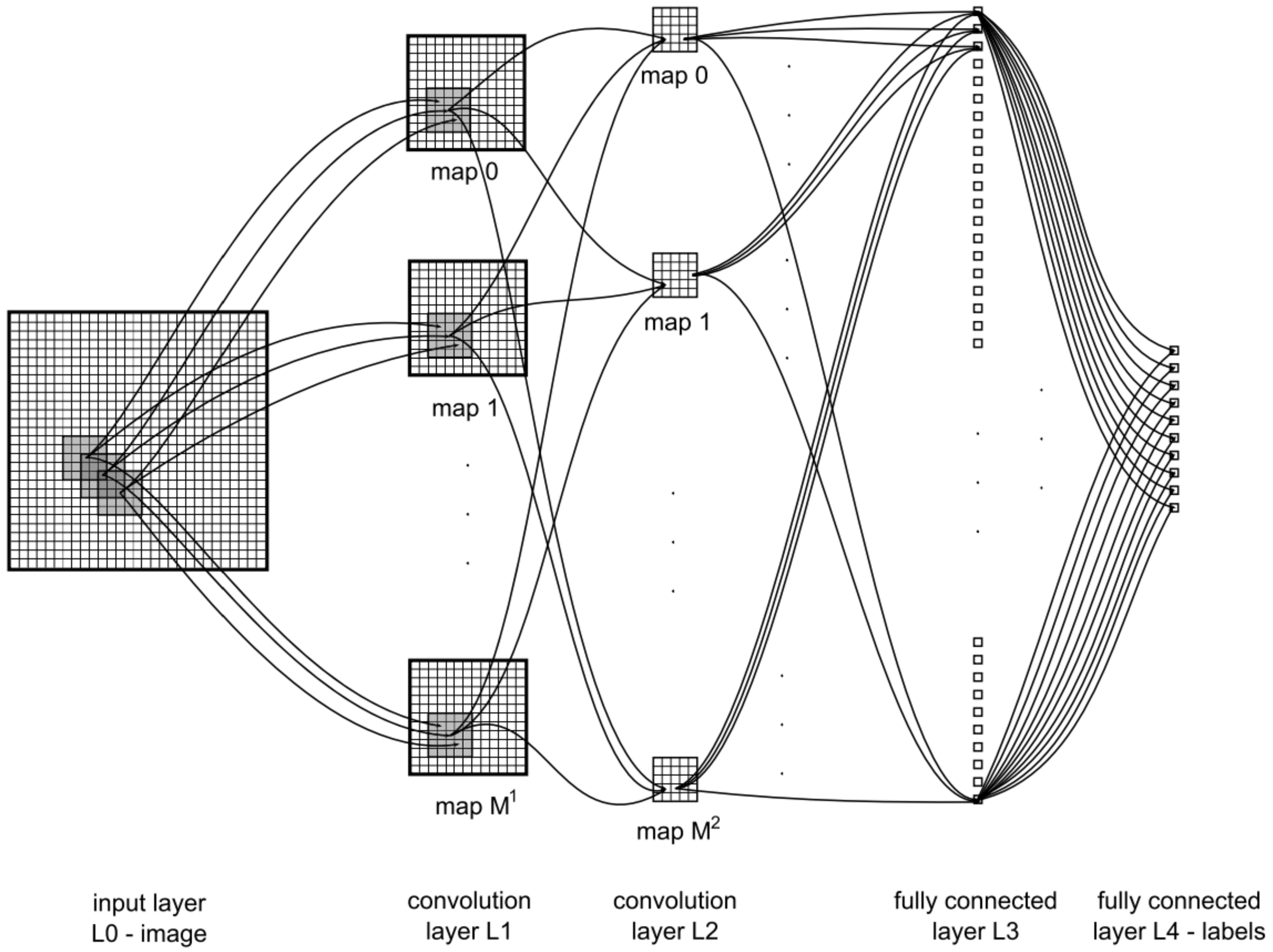
Complex & Hypercomplex

Receptive Fields



D. Ciresan, IDSIA

Shared weights

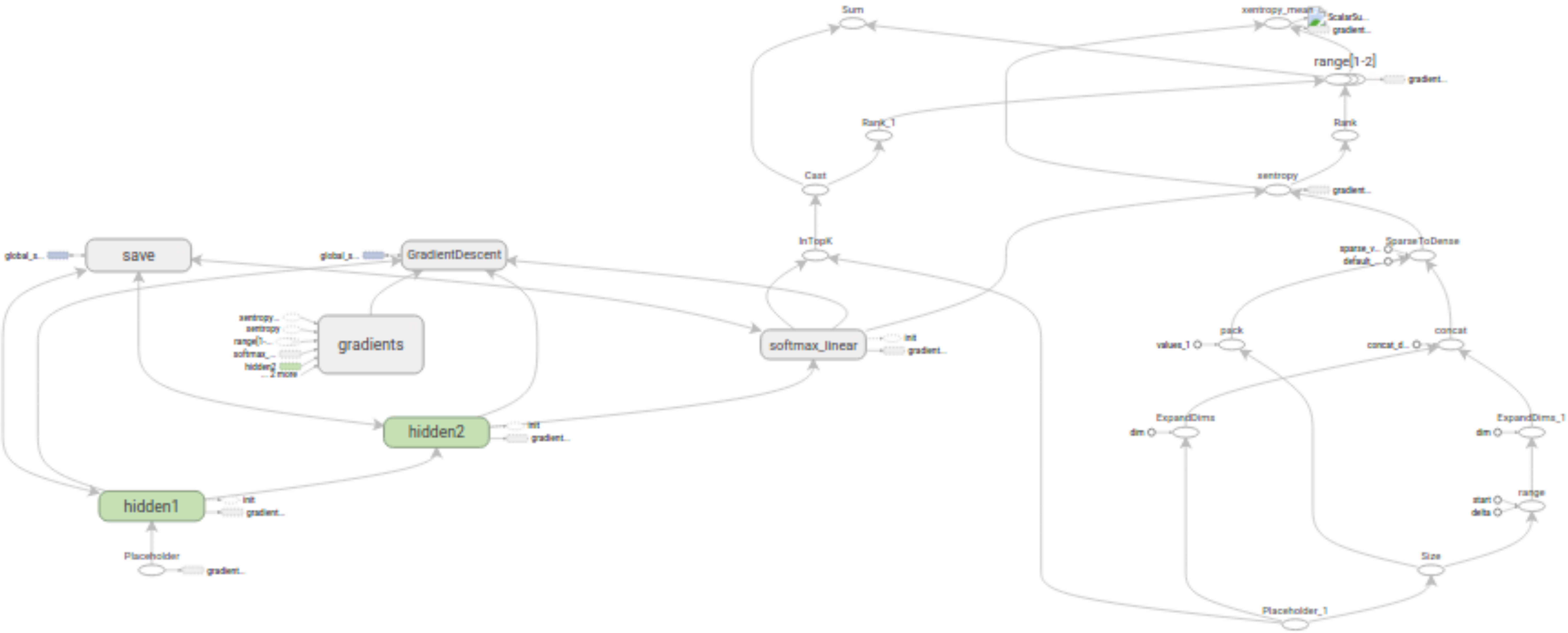


Each input is modified by a *weight,* which is the relative amplitude of the connection between two nodes and it defines the amount of influence one node will have on the other.

Tensor flow & keras

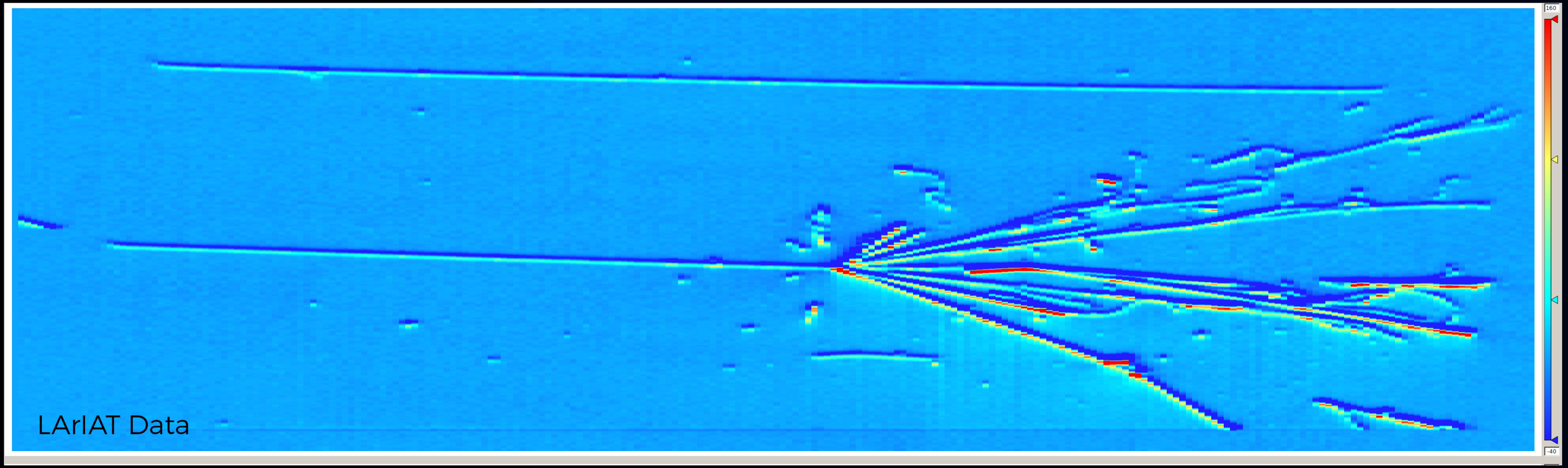
We have designed a way to take reconstructed TPC images and convert them to an input for TensorFlow. We are currently in the process of designing the multi-layered structure of the CNN to test the first run of training.

Tensorflow & keras



Next Steps

Currently, we are working to build the framework of our Convolutional Neural Network and use training sets we have created from our data to teach it to classify each particle interaction. By using LArIAT data with known inputs and outputs we can then prepare our CNN for future liquid argon neutrino experiments such as DUNE.



To the LArIAT Collaboration,
Dr. Jennifer Raaf,
Dr. Jason St. John,
Dr. Roberto Acciarri,
Gregory Pulliam,
Daniel Smith,
Derek Walker,
and the SIST Committee.

thank you!